



Southwestern Region

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Intellect plus the Amplifiers of Intellect

May 11, 1965

Dear Sir:

In answer to your recent inquiry, we are enclosing a copy of the introduction section to the C-E-I-R Network Equivalent Analysis Users Guide. This section contains information describing the capacity, capability, and application of the program; another in a series of C-E-I-R programs specifically prepared for the Electric Utility Industry.

If we can supply you with further information concerning our capability or the use of the C-E-I-R Load Flow, Short Circuit, Transient Stability, or Network Equivalent proprietary programs at any of our computer centers, do not hesitate to contact me.

Sincerely,

Charles W. King, Manager
Electric Utility Services

Enclosure

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BACKGROUND AND ACKNOWLEDGEMENT

The tremendous growth of the Electric Utility Industry has in itself led to the necessity to represent larger electrical networks in all types of Network Analyses. Present power pooling activity within the industry also results in large networks due to the necessity to study technical problems representing the combined networks of several systems. Although the advent of high speed digital computers has made feasible the study of larger and more detailed electrical networks, it is sometimes still necessary and is often desirable and economical to reduce these large networks to smaller equivalent networks for further study.

This Users Guide describes the C-E-I-R Network Equivalent Program available at C-E-I-R Computing Centers in most major cities in the country. Not only does this program enable the Utility Industry to economically perform large electrical network reductions, but through the use of this procedure, the smaller equivalent networks obtained enable more economical network analyses to be performed.

C-E-I-R, INC. is prominent in conducting studies for the Electric Utility Industry not only in Network Equivalent Analysis but also in Load Flow, Short Circuit and Transient Stability Analyses, as well as assisting in the solution of many other technical problems. Almost unlimited electronic computer resources at the disposal of experienced and knowledgeable analysts, programmers and electric utility specialists, are available at C-E-I-R, INC.

At C-E-I-R, a wide range of services are offered which include consultations that evaluate the systems engineering problems and terminate with problem solution using the C-E-I-R computer program. The features and capability of the Network Equivalent Program are outlined in this introduction section. Although the program is quite flexible and can be used to obtain several types of equivalents, it is expected that use of the program by the Utility Industry will lead to modifications and improvements.

In accordance with past policy of the Electric Utility Specialists at C-E-I-R, INC., this Network Equivalent Analysis Program has been developed such that data, previously prepared for the other C-E-I-R Electric Utility Applications Programs, may be used in this program. It is recognized that a Network Equivalent Analysis is usually made in connection with Load Flow, Short Circuit and/or Transient Stability Analysis and with the user in mind, C-E-I-R has continued to coordinate these analyses. The C-E-I-R program was developed under the direction of Charles W. King.

FEATURES OF THE PROGRAM

PROGRAM CAN CALCULATE:

- POSITIVE SEQUENCE SHORT CIRCUIT EQUIVALENTS
- ZERO SEQUENCE SHORT CIRCUIT EQUIVALENTS, EXCLUDING MUTUAL IMPEDANCE EFFECTS
- ZERO SEQUENCE SHORT CIRCUIT EQUIVALENTS, INCLUDING MUTUAL IMPEDANCE EFFECTS
- TRANSIENT STABILITY EQUIVALENTS
- IMPEDANCE EQUIVALENTS

PROGRAM CAPACITY:

FOR ZERO SEQUENCE EQUIVALENTS INCLUDING MUTUAL IMPEDANCE EFFECTS

- 325 CIRCUITS (LINES PLUS TRANSFORMERS + SOURCES)
- 225 BUSES
- 75 RETAINABLE BUSES
- 100 = MAXIMUM (CIRCUITS - BUSES)

FOR ALL OTHER TYPES OF EQUIVALENTS

- 900 CIRCUITS (LINES PLUS TRANSFORMERS)
- 500 BUSES
- 75 RETAINABLE BUSES

INPUT DATA REQUIRED:

- BASIC DATA (A PREVIOUSLY PREPARED C-E-I-R LOAD FLOW, SHORT CIRCUIT, OR TRANSIENT STABILITY DATA DECK WHICH CONTAINS THE NECESSARY CIRCUIT AND BUS DATA MAY BE USED)

- AUXILIARY DATA (TO SUPPLEMENT THE BASIC DATA. IT ALWAYS CONTAINS THE LISTING OF THE BUSES TO BE RETAINED AND MAY CONTAIN OTHER DATA SUCH AS SOURCE IMPEDANCE DATA FOR A SHORT CIRCUIT EQUIVALENT USING LOAD FLOW INPUT)

PROGRAM USAGE

The C-E-I-R Network Equivalent Program allows an infinite number of studies to be processed in a series. Each study must contain the necessary basic and auxiliary data as well as all necessary associated Control Cards to indicate the processing functions to be performed.

The use of previously prepared Load Flow, Short Circuit and Transient Stability data decks (intact with control cards) greatly simplifies the preparation of the basic data needed for an equivalent study. There are some restrictions on the use of such decks however, for the various types of equivalents due to the necessity for existence of certain data. Should such data contain additional information not needed in the equivalent program, it will be discarded by the program.

As described in Section 2, the input data for a Short Circuit Equivalent must contain the bus source impedances. If a basic data deck is used which has been compiled according to the C-E-I-R Short Circuit requirements, this source impedance information will be within the bus data. If a Load Flow prepared basic deck is used, the source impedances must be described within the auxiliary data. For a Transient Stability prepared data deck, two alternatives exist. If source impedances are described in the auxiliary data, they will be used. If no source impedances are in the auxiliary data, the transient impedances in the Transient Stability bus coordination data will be used.

When Load Flow or Transient Stability prepared data is used for a Positive Sequence Short Circuit Equivalent, the transformer taps and line charging may be optionally considered.

Only a Short Circuit prepared deck may be used for a Zero Sequence Short Circuit Equivalent because only such decks contain zero sequence impedance and inductive mutual coupling information.

Section 3 describes the Transient Stability Equivalent obtained by representing one common internal generator bus to which all transient impedances are connected. For this type equivalent, only a Transient Stability prepared data deck can be used as the basic data.

As Section 4 describes, it is often desired to obtain an Impedance Equivalent where all bus generation, loads, and shunt paths are ignored. For this type equivalent, a previously prepared Load Flow, Short Circuit or Transient Stability basic data deck may be used. Again, any transformer taps and line charging values in the data may be optionally considered.

Included in the output reports for each study is a printout of the input data as well as a report describing the resultant equivalent. Since the range of the impedances in the resultant equivalent can vary, they are classified as to those less than 100%, those exceeding 100% and those exceeding 1,000%.

PROGRAM MATHEMATICS

To obtain a Zero Sequence Short Circuit Equivalent which includes the effects of inductive mutual coupling, the Network Equivalent Program establishes a set of mesh or loop equations with the zero sequence network and mutuals. Using these equations, a fault is applied to each bus which it is desired to obtain in the equivalent network. Voltages are also obtained at each retained bus for each fault. Using these values, a "self-and-mutual drop" matrix is established. The inverse of this matrix is the self and mutual admittance matrix from which the impedances of the retained network can be determined. This procedure includes the effect of the mutual coupling and results in an equivalent impedance from each retained bus to every other retained bus.

For all other types of equivalents, the program forms a nodal admittance matrix of the original network and reduces this matrix by a process of nodal elimination to only the desired equivalent network. Under such a process, a network where only a few buses are reduced will result in an equivalent which will not have an impedance path from each retained bus to every other retained bus.